Epidemiology Study of Swimmers in Nonpoint Source Polluted Marine Recreational Waters from San Diego, CA

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Today's Road Map

- **Background**
  - **Study questions**
- **Study design**
- **Epidemiological recruiting**
- **Preliminary water quality results**
  - **Traditional indicators and new indicators**
- **Next steps**

Background

- Southern California has a tremendous amount of beach use
  - 175 million beachgoers annually
- Most treated sewage is discharged more than five miles offshore
  - 60 to 100 m depth
- $3 M in beach monitoring each year
  - still have lots of beach postings and closures

Mission Bay is the Poster Child

- Heavily used aquatic park
- Receives numerous nonpoint sources
  - urban storm drains
  - wildlife (I.e. birds)
- More than 100 days of beach postings in 1998

Study Questions

- **Is there a health risk of swimming in Mission Bay?**
  - **Comparison of swimmers and non-swimmers**
- **Can we relate health risk to bacterial indicator concentrations?**
  - **Comparison among swimmers at different times and locations**
- **Can we relate health risk to non-traditional microbiological indicators?**
  - **Virus and Phage**
  - ***Bacteroides* and *Enterococcus faecalis***

General Approach

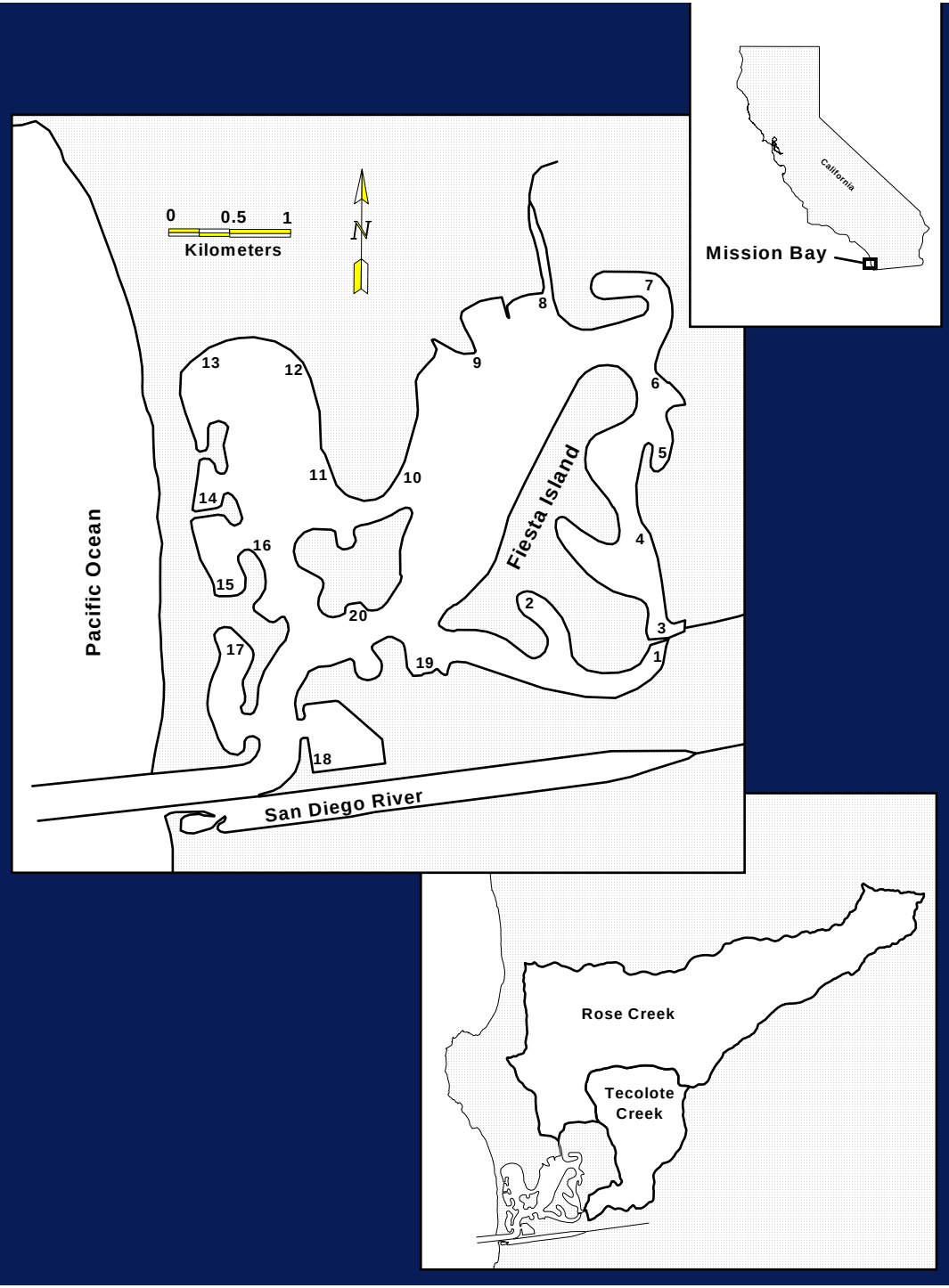
- **Pilot study**
  - **identify when and where most swimming occurs**
- **Retrospective epidemiological design**
  - **mimicked National Epidemiology Study**
- **Intensive water quality measurements to describe exposure**

Pilot Study

- Helicopter surveys of swimming activity
- Six beaches represented over 75% of the swimming activity
  - close to parking, amenities
- Trends in historical water quality
  - unpredictable forecasting in space and time

Study Beaches

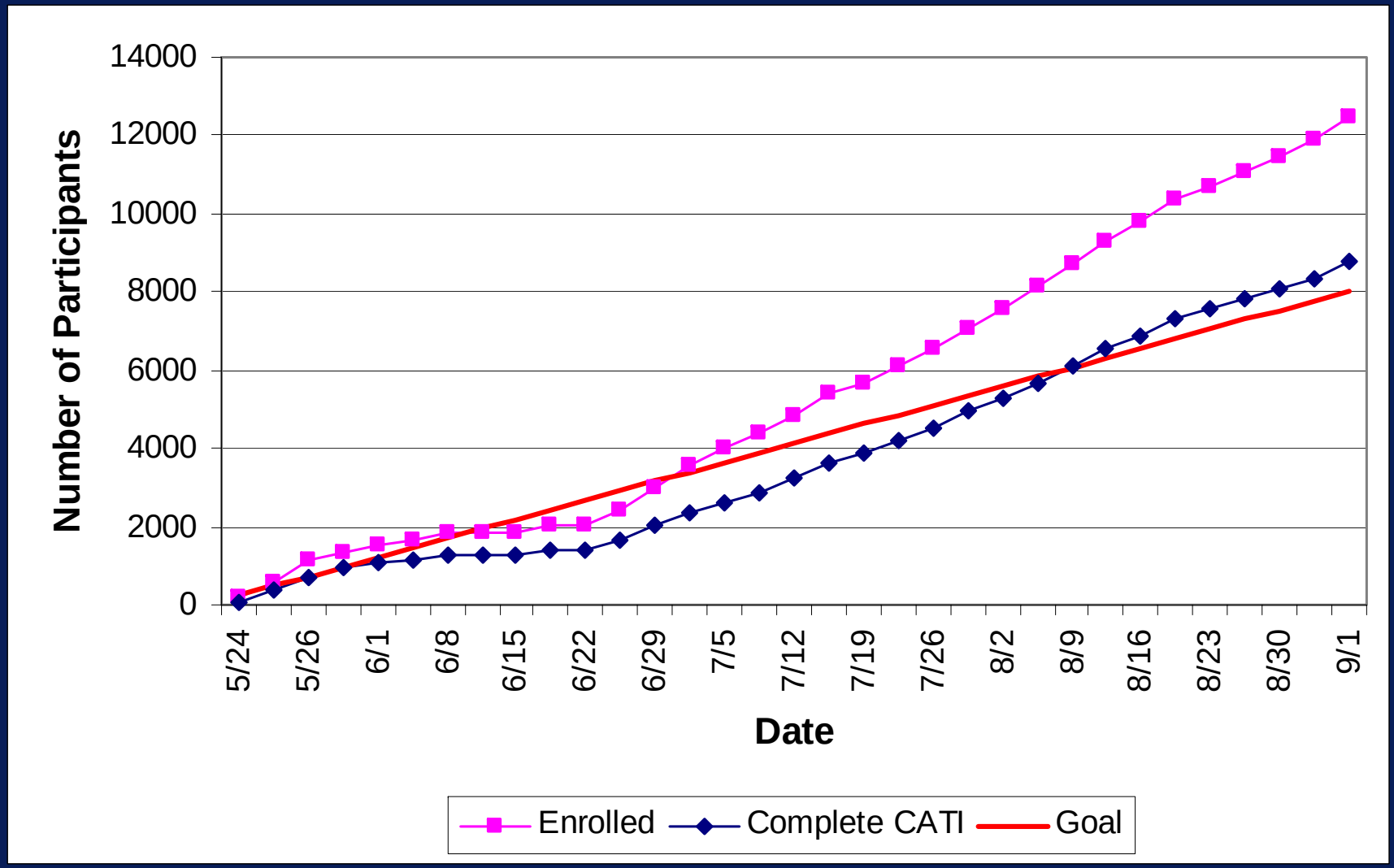
Bonita Cove
Crown Pt Shores
Tecolote Ck/Shores
Leisure Lagoon
Visitors Center
De Anza Cove



Recruitment Procedures

- **Study center set up at each beach**
  - **every summer weekend and holiday**
- **Beach-goers approached by interviewers**
  - **consent obtained**
- **Return to study center as they leave, complete beach survey**
  - **receive incentive for participation**
  - **those who failed to return were telephoned within 2-days**
- **Telephoned 10-14 days later to complete illness survey**

Actual Enrollment vs. Goal
All Subjects



Prior Large Recreational Water Studies

Cabelli 1983	USA	Marine	26,686	cohort
Cabelli 1983	Egypt	Marine	23,080	cohort
Dufour 1984b	USA	Fresh	21,777	cohort
Cheung et al. 1990	Hong Kong	Marine	18,741	cohort
Kueh et al. 1995	Hong Kong	Marine	18,122	cohort
Pike 1994	UK	Marine	16,569	cohort
Haile et al. 1999	USA	Marine	11,686	cohort
Lightfoot 1989	Canada	Fresh	9,296	cohort
MISSION BAY 2003	USA	Marine	8,806	cohort
Ferley et al. 1989	France	Fresh	5,737	cohort

Demographics of Study Population
Race and Gender

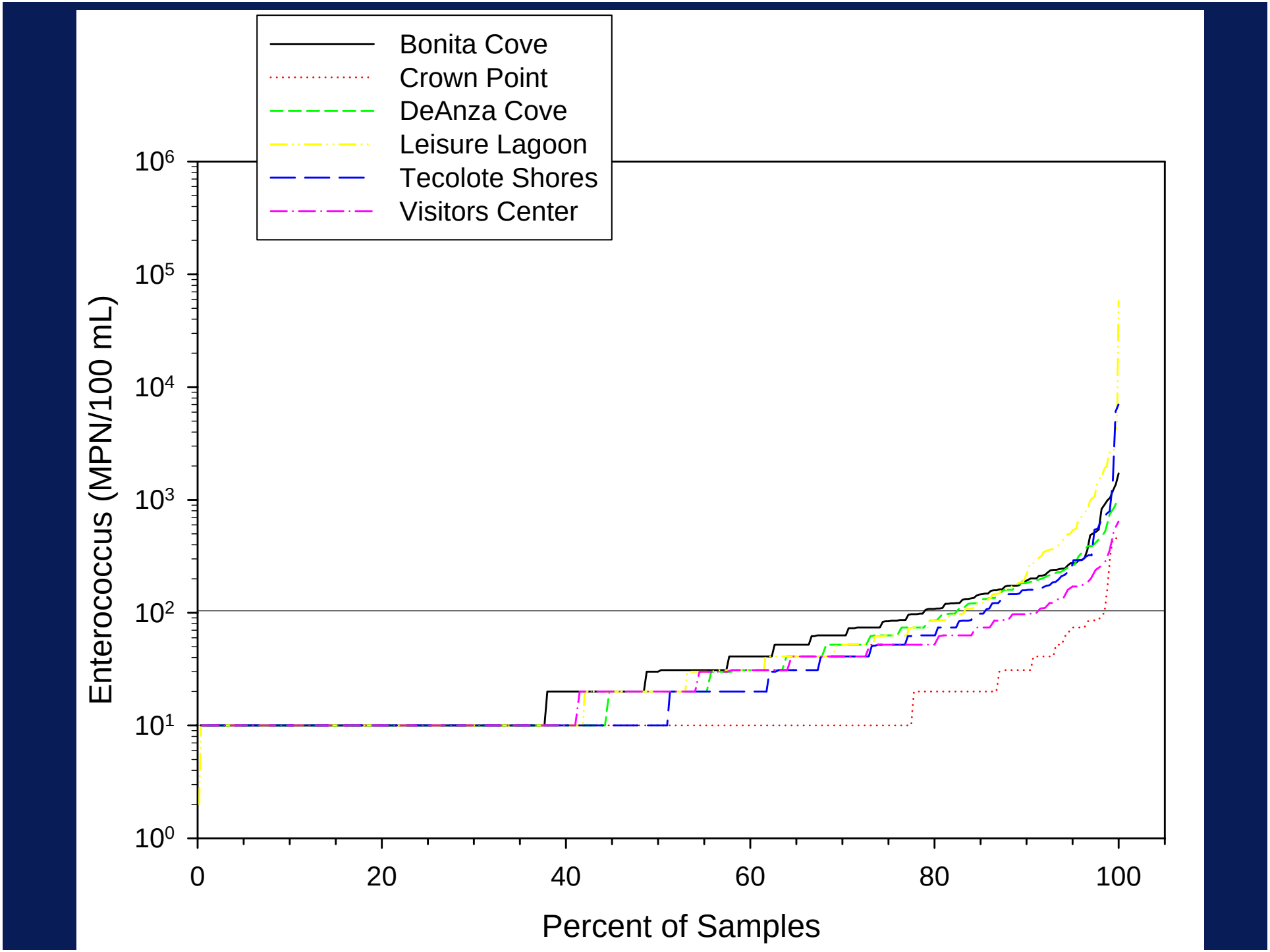
	% Swimmers	% Non-swimmers
	(N=4966)	(N=3740)
Gender		
Male	46.5	43.2
Race		
White	23.8	34.9
African American	3.3	5.2
American Indian/Alaskan	0.7	0.7
Asian/Pacific Islander	3.6	7.5
Hispanic/Latino	61.4	43.2
Mixed Race	4.9	4.4
Other	1.9	3.4
Missing	0.5	0.7

Water Related Activity Among Swimmers
Time of Exposure (N=4966)

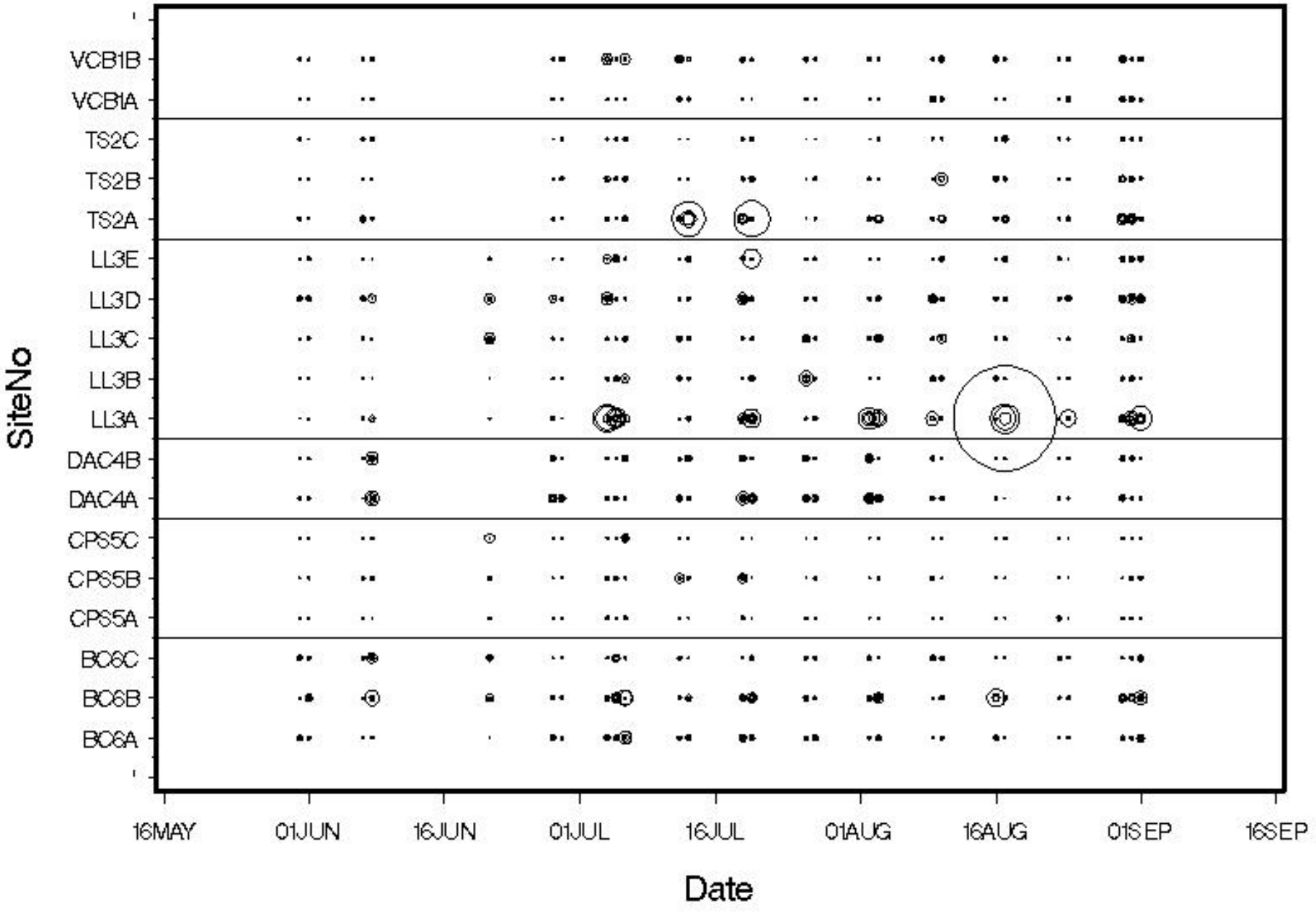
Time of Exposure	% Exposed
Before 10 am	9.2
Between the hours of 10am -12pm	15.7
Between the hours of 12pm-2pm	56.8
Between the hours of 2pm - 4pm	36.5
After 4pm	18.2

Basic Water Quality Design

- Every summer weekend and holiday
  - Six beaches
- Between 2 and 5 sites per beach
  - Density dependent on beach length and expected swimmer density
- Sampled hourly from 12:30 to 3:30
  - Total and fecal coliforms by MF
  - Enterococcus by Idexx
- Single beach composite at 12:30
  - Phage, virus, Bacteroides, E. faecalis
  - Total and fecal by Idexx
  - Enterococcus by MF


Bonita Cove
Crown Point
DeAnza Cove
Leisure Lagoon
Tecolote Shores
Visitors Center
Enterococcus (MPN/100 mL)
10^6
10^5
10^4
10^3
10^2
10^1
10^0
0
20
40
60
80
100
Percent of Samples

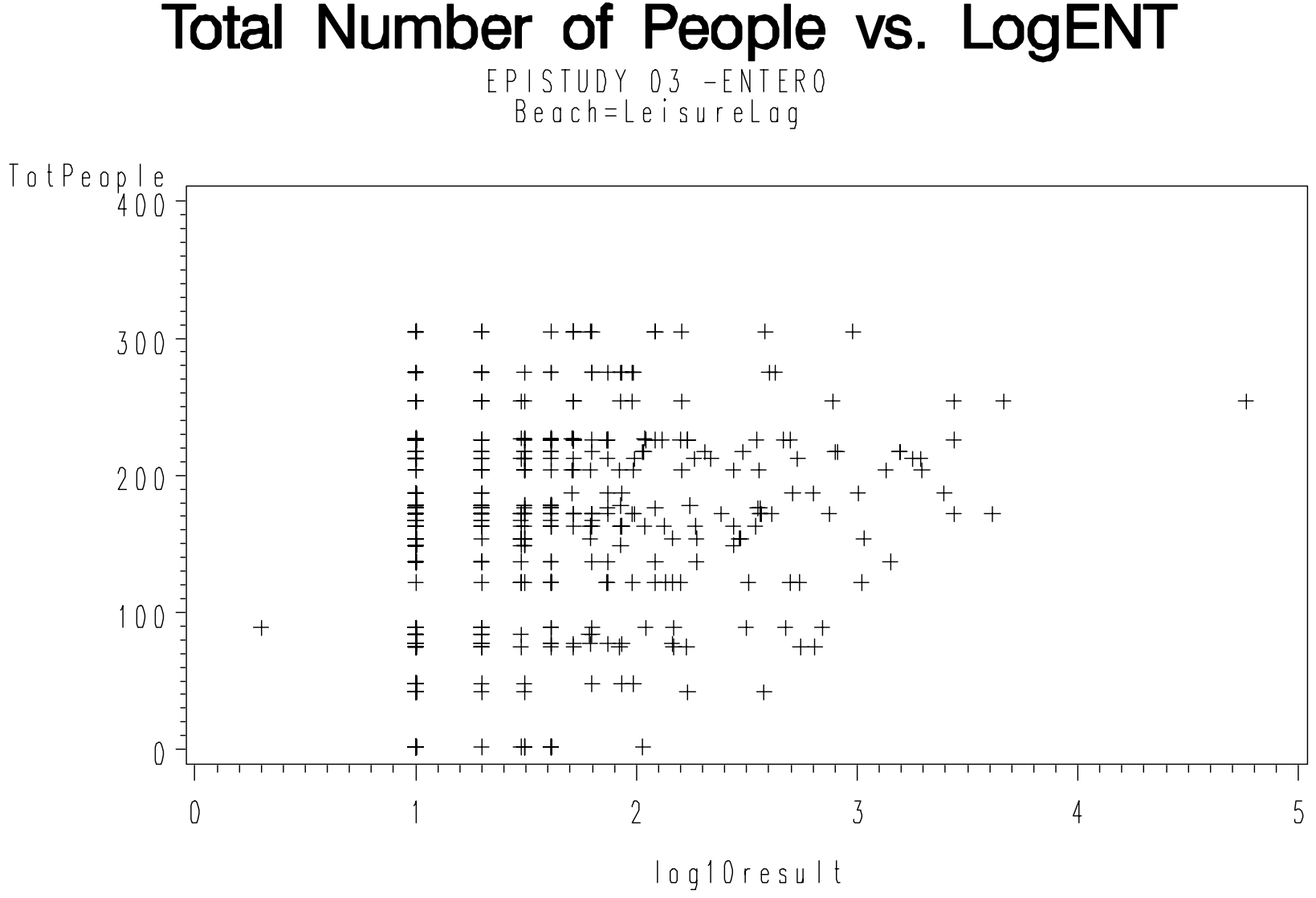
ENTEROCOCCUS



Relationships with Other Factors

- Number of beachgoers
- Number of swimmers
- Tide

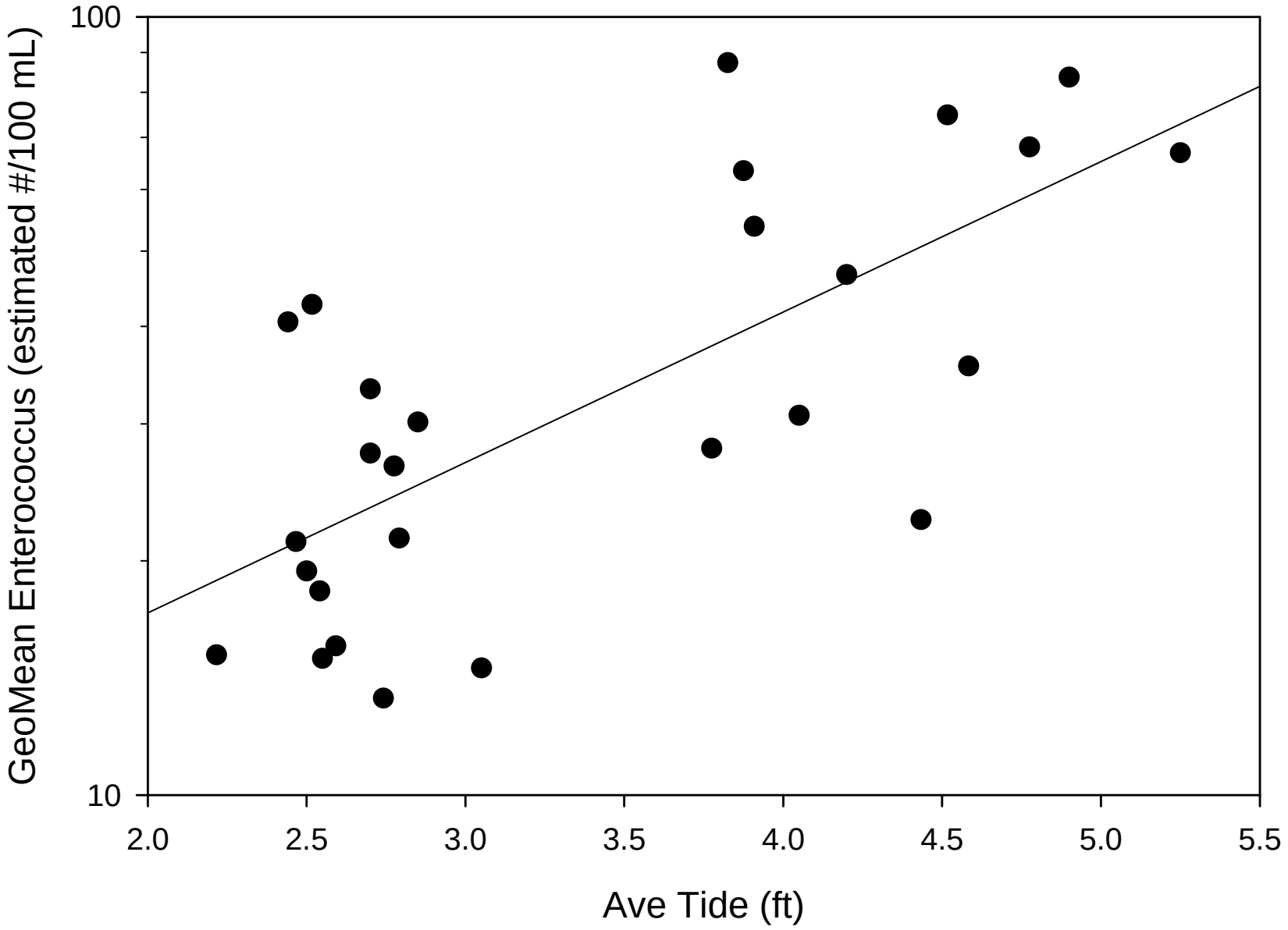
Total Number of People vs. LogENT



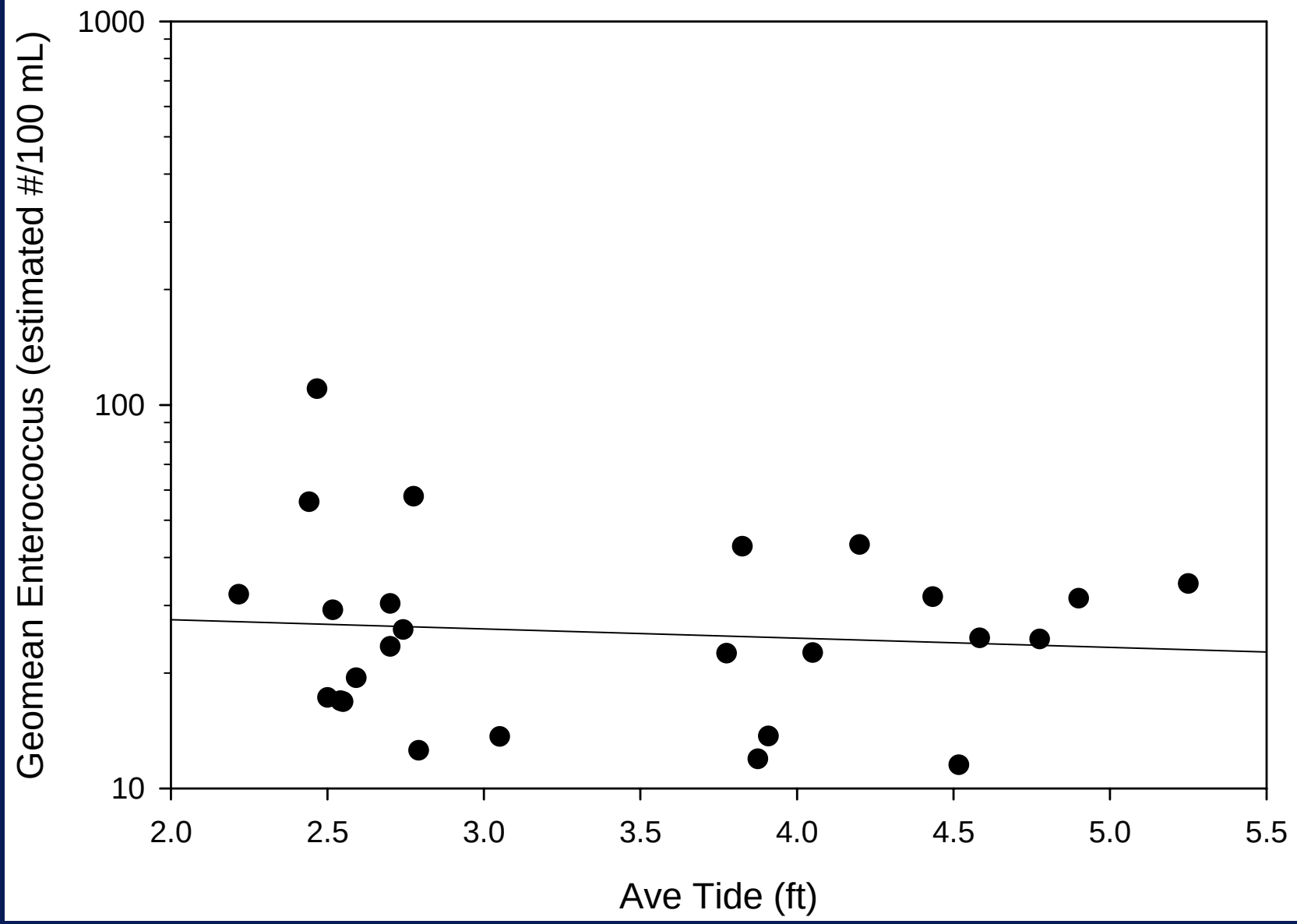
Effect Of Tide

Beach	Corr Coeff
Bonita Cove	0.54
Crown Point	0.16
De Anza Cove	0.00
Leisure Lagoon	0.71
Tecolote Shores	0.50
Visitors Center	0.10

Leisure Lagoon



Visitors Center

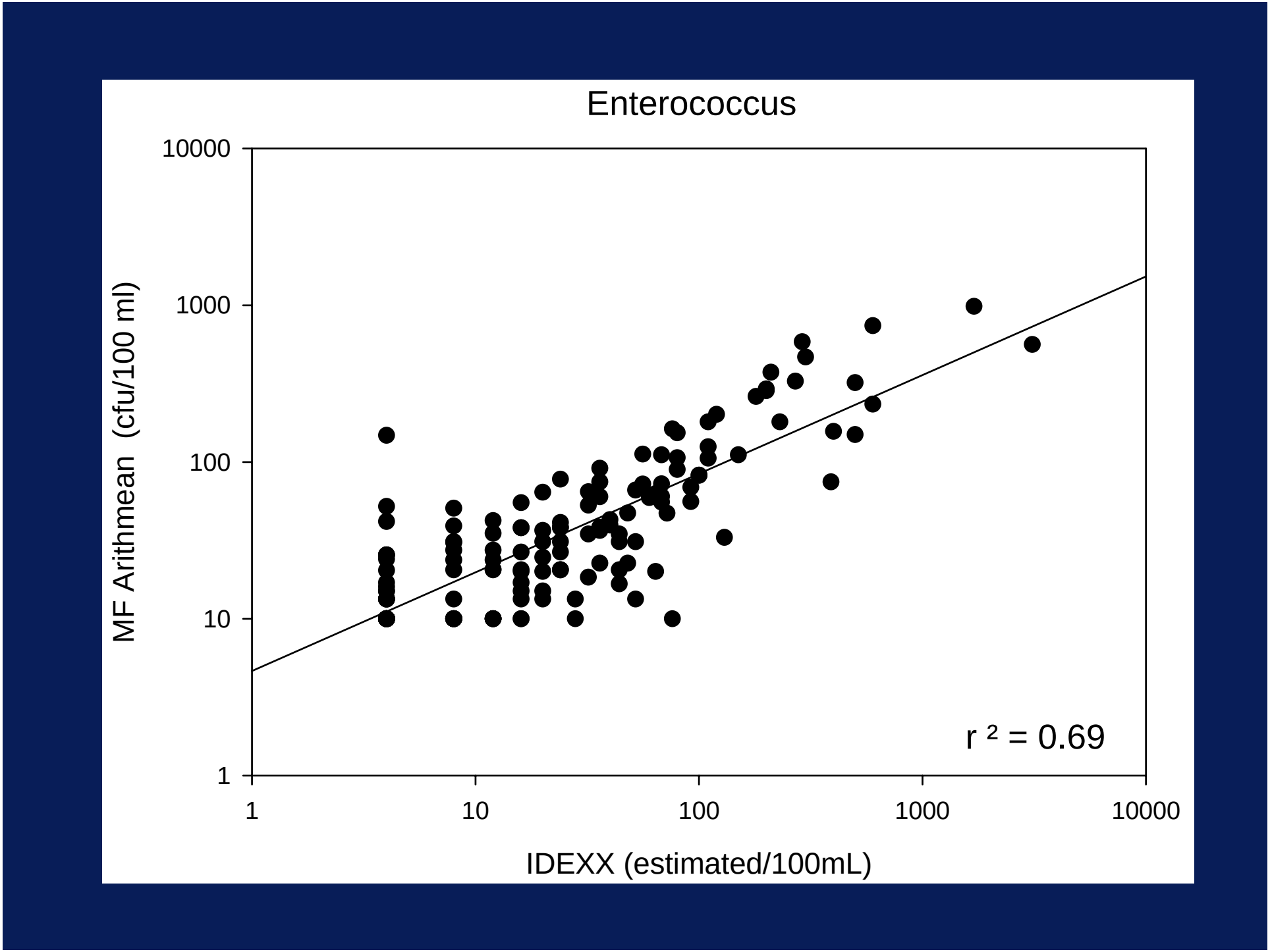


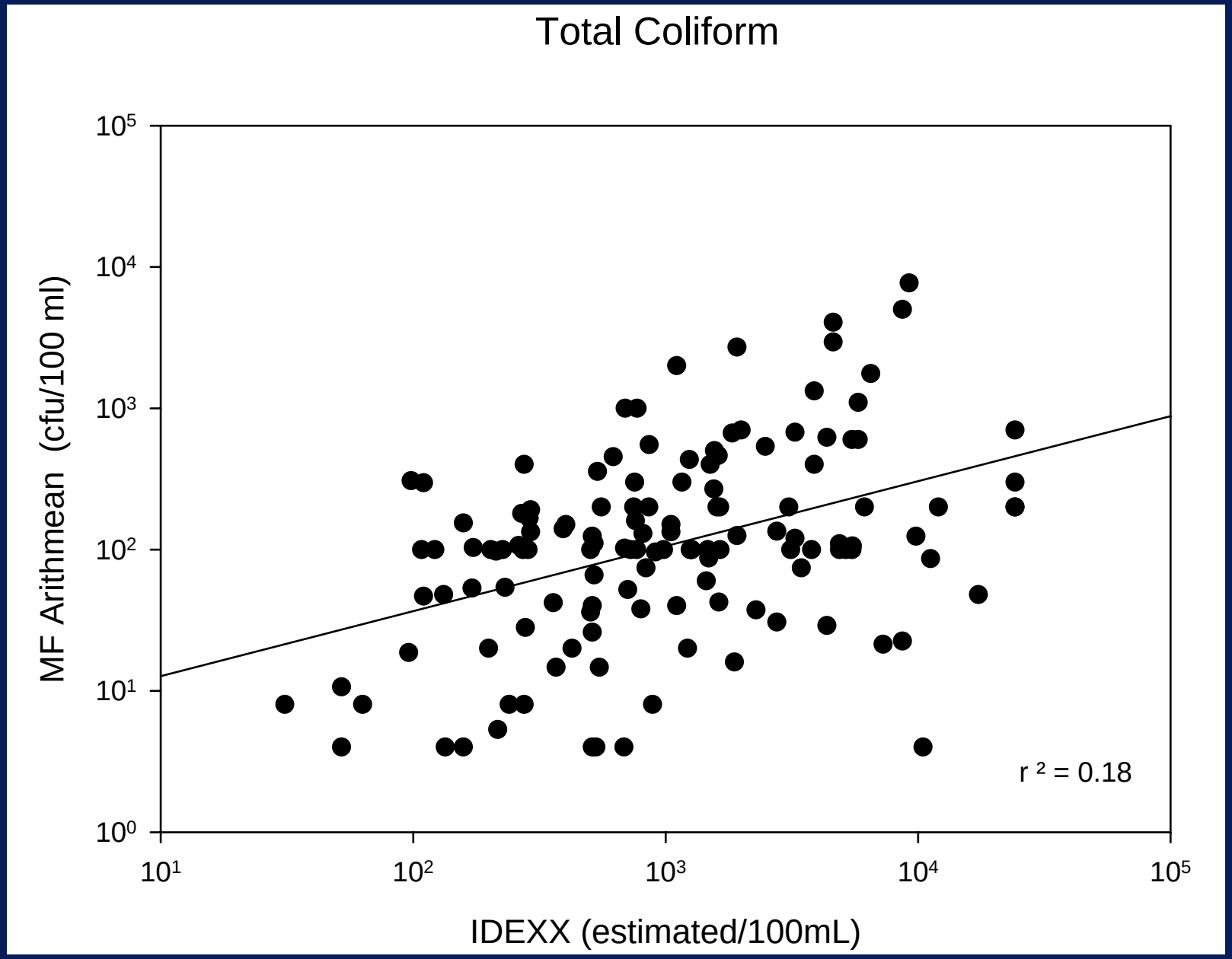
Comparison Of Indicators

- Different methods for the same indicators
- Traditional indicators versus newer bacterial indicators

Different Methods

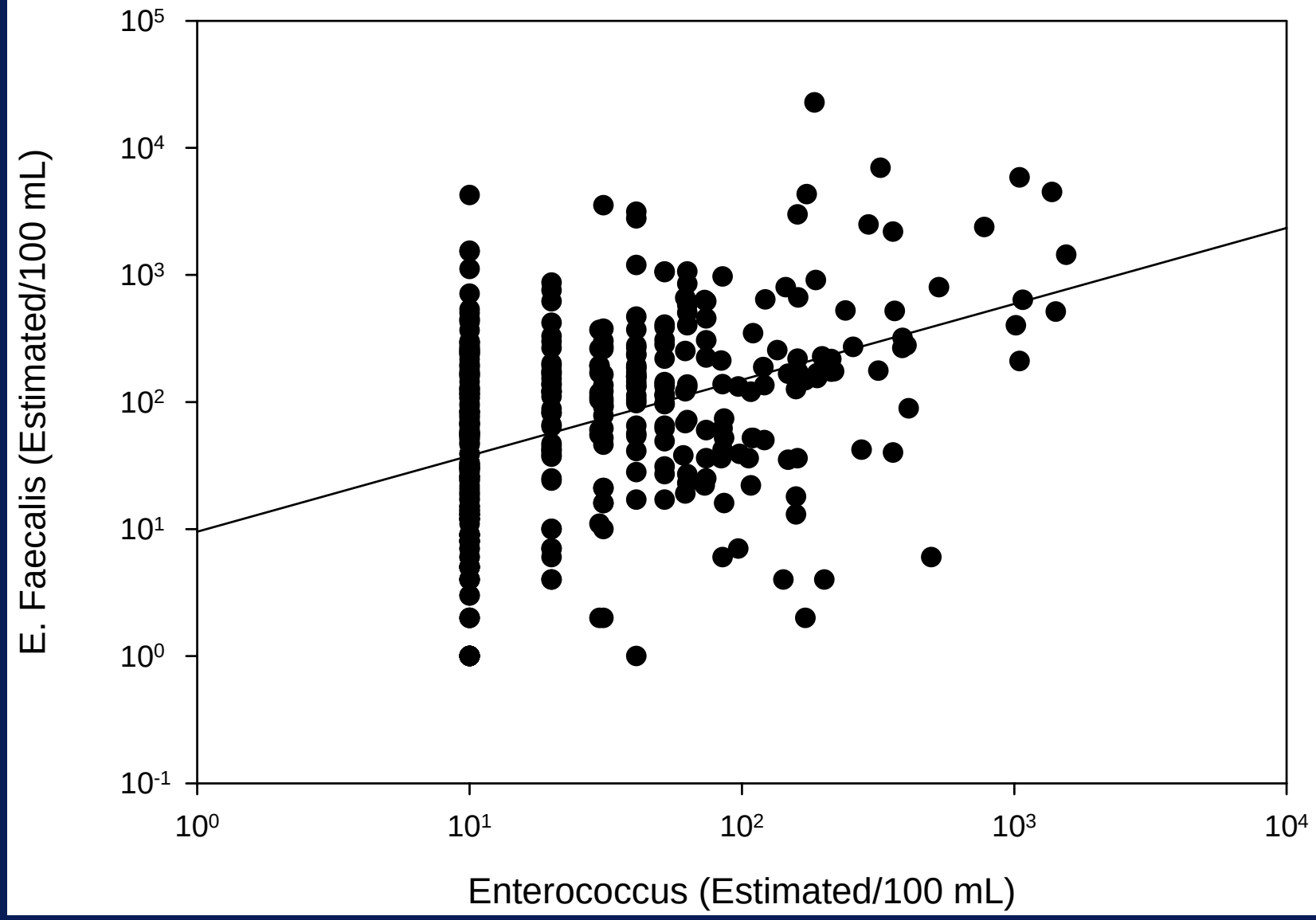
- MF vs Idexx
- Need for compositing
- Enterococcus methods well correlated
  - less so for total coliform

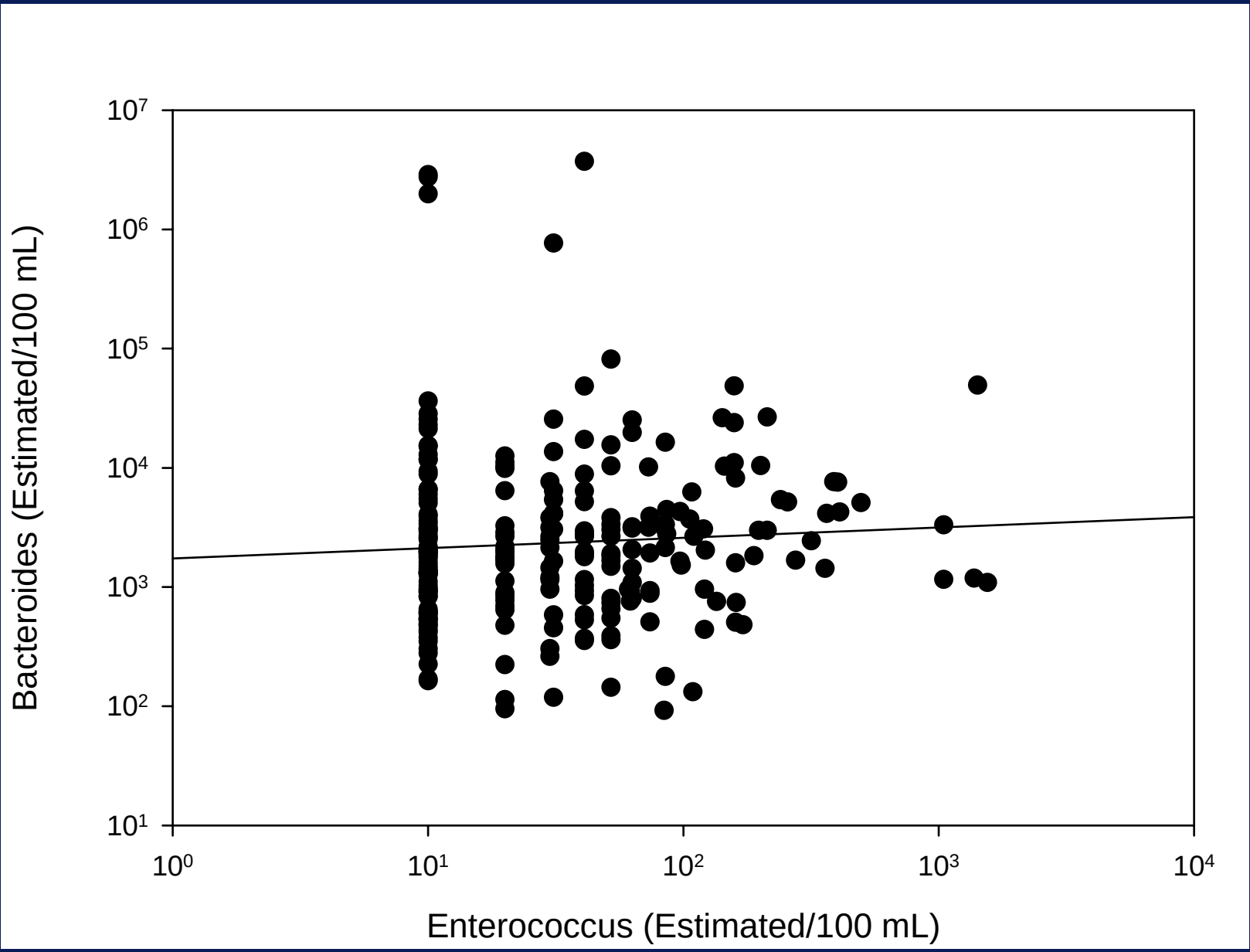

Enterococcus
10000
1000
100
10
1
MF Arithmean (cfu/100 ml)
1
10
100
1000
10000
IDEXX (estimated/100mL)
r ² = 0.69


Total Coliform
MF Arithmean (cfu/100 ml)
IDEXX (estimated/100mL)
10^0
10^1
10^2
10^3
10^4
10^5
r ² = 0.18

Correlation Matrix For Different Indicators

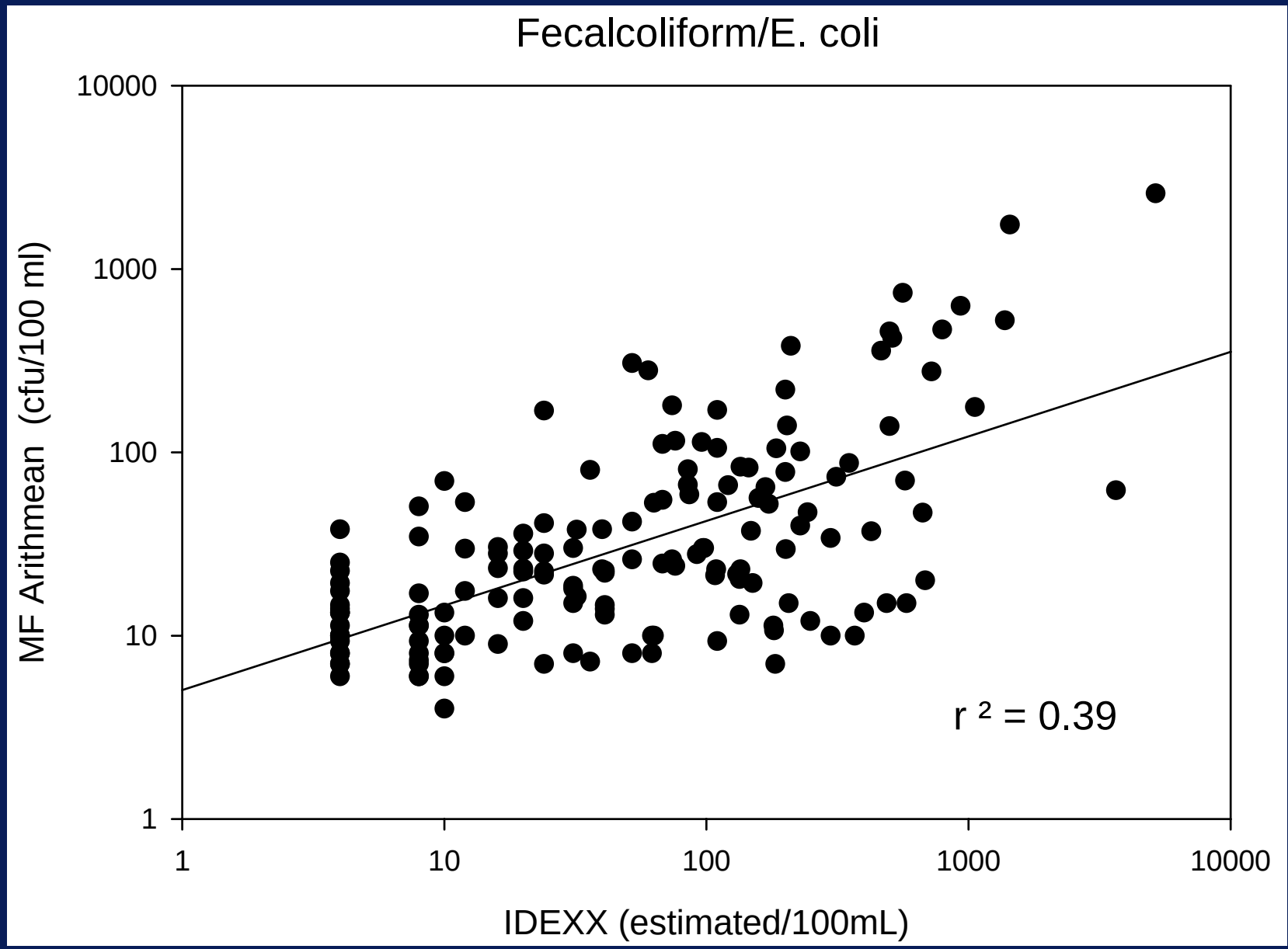
	TC	FC	Entero	E. Faecalis	Bacteroides
TC		0.51	0.40	0.28	0.01
FC			0.35	0.17	0.01
Entero				0.24	0.01
E. Faecalis					0.01
Bacteroides					

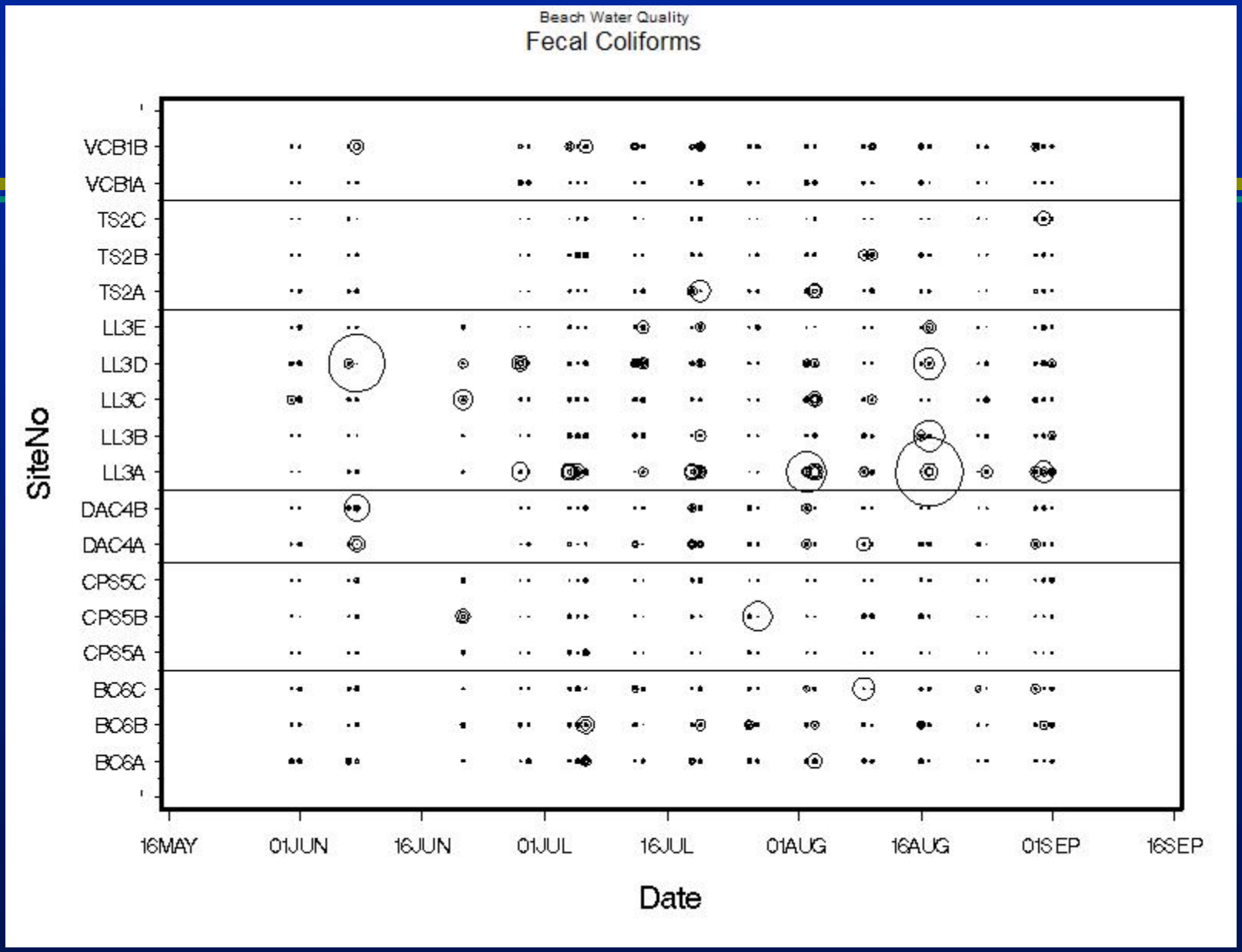

E. Faecalis (Estimated/100 mL)
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^0
10^1
10^2
10^3
10^4
Enterococcus (Estimated/100 mL)

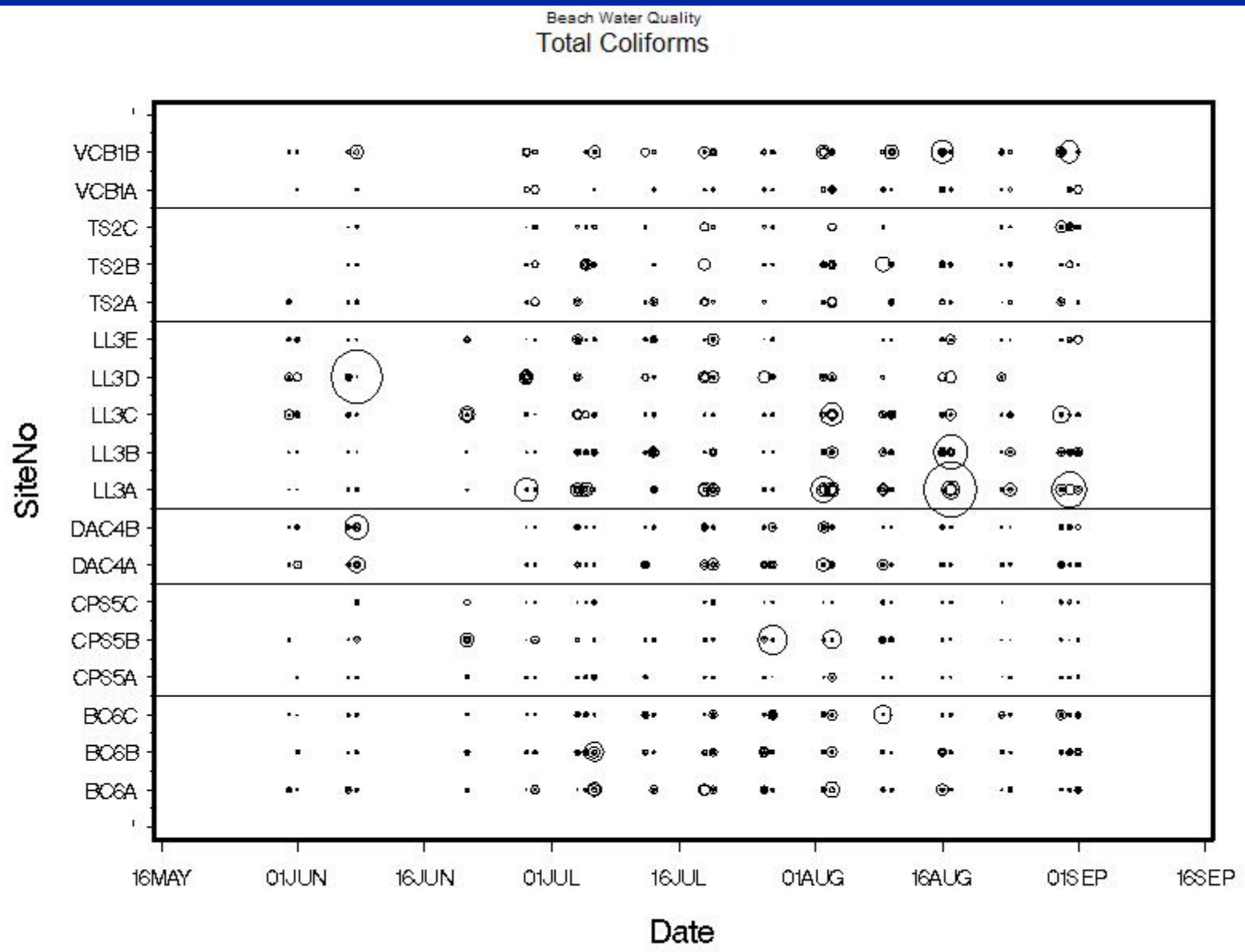

Bacteroides (Estimated/100 mL)
10^7
10^6
10^5
10^4
10^3
10^2
10^1
10^0
10^1
10^2
10^3
10^4
Enterococcus (Estimated/100 mL)

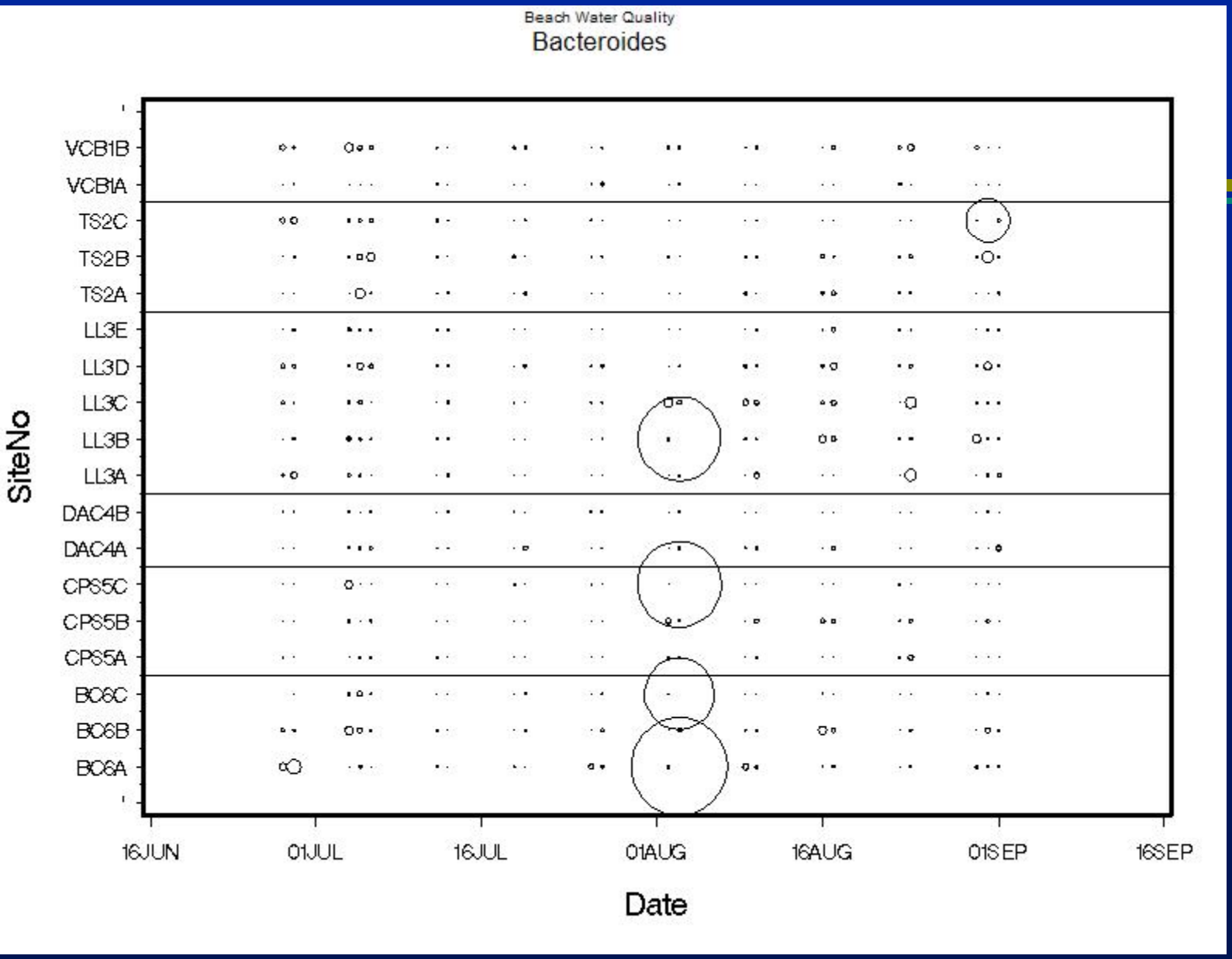
Next Steps

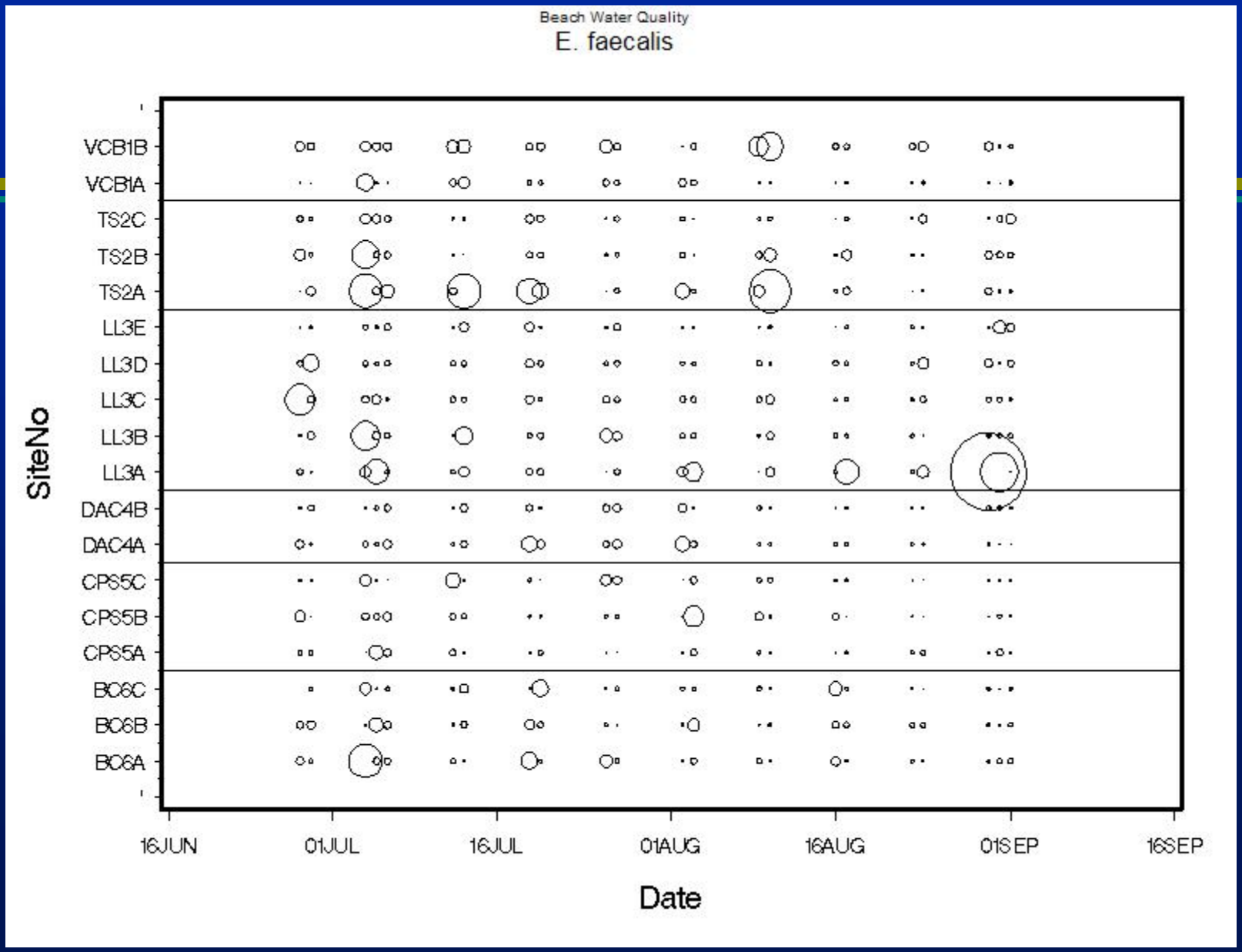
- **Epidemiological data analyses underway**
  August 2004
- **Presentation at the National Beach Conference**
  October 2004
- **Final report**
  Dec 2004

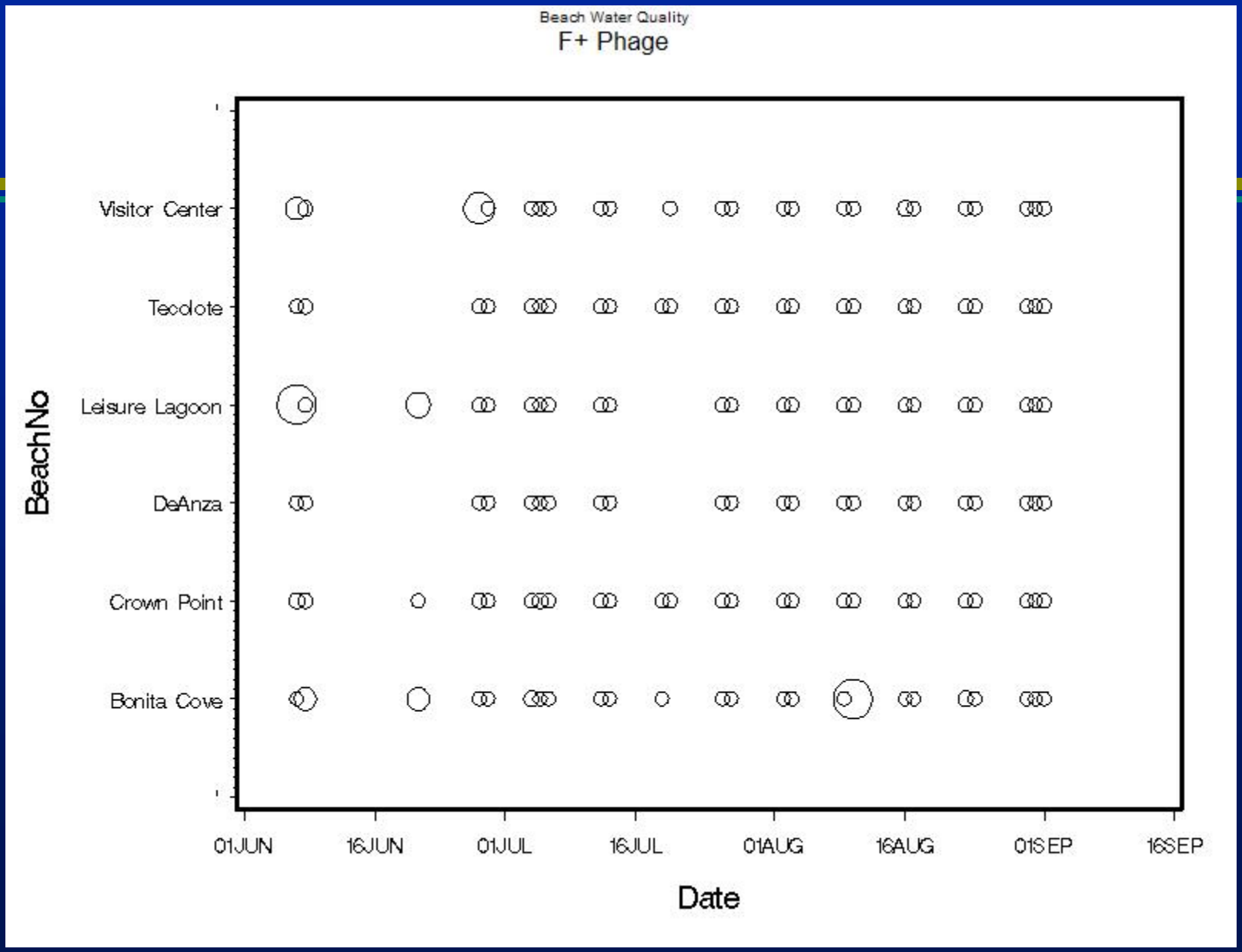

Fecalcoliform/E. coli
MF Arithmean (cfu/100 ml)
10000
1000
100
10
1
1
10
100
1000
10000
IDEXX (estimated/100mL)
r ² = 0.39


Beach Water Quality
Fecal Coliforms
SiteNo
VCB1B
VCB1A
TS2C
TS2B
TS2A
LL3E
LL3D
LL3C
LL3B
LL3A
DAC4B
DAC4A
CPS5C
CPS5B
CPS5A
BC6C
BC6B
BC6A
16MAY
01JUN
16JUN
01JUL
16JUL
01AUG
16AUG
01SEP
16SEP
Date


Beach Water Quality
Total Coliforms
SiteNo
VCB1B
VCB1A
TS2C
TS2B
TS2A
LL3E
LL3D
LL3C
LL3B
LL3A
DAC4B
DAC4A
CPS5C
CPS5B
CPS5A
BC6C
BC6B
BC6A
16MAY
01JUN
16JUN
01JUL
16JUL
01AUG
16AUG
01SEP
16SEP
Date


Beach Water Quality
Bacteroides
SiteNo
VCB1B
VCB1A
TS2C
TS2B
TS2A
LL3E
LL3D
LL3C
LL3B
LL3A
DAC4B
DAC4A
CPS5C
CPS5B
CPS5A
BC6C
BC6B
BC6A
16JUN
01JUL
16JUL
01AUG
16AUG
01SEP
16SEP
Date


Beach Water Quality
E. faecalis
SiteNo
VCB1B
VCB1A
TS2C
TS2B
TS2A
LL3E
LL3D
LL3C
LL3B
LL3A
DAC4B
DAC4A
CPS5C
CPS5B
CPS5A
BC6C
BC6B
BC6A
16JUN
01JUL
16JUL
01AUG
16AUG
01SEP
16SEP
Date


Beach Water Quality
F+ Phage
BeachNo
Visitor Center
Tecolote
Leisure Lagoon
DeAnza
Crown Point
Bonita Cove
01JUN
16JUN
01JUL
16JUL
01AUG
16AUG
01SEP
16SEP
Date